# DATA PROCESSING DIGEST

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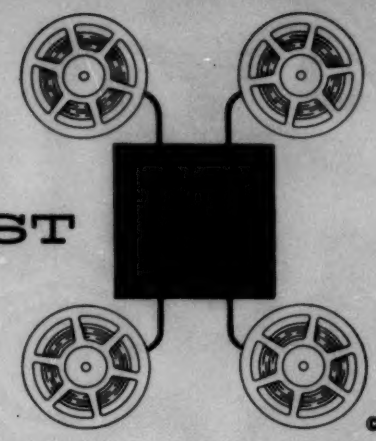


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## Management Sciences

### THE ROLE OF MANAGEMENT GAMES IN EDUCATION AND RESEARCH

*Kalman J. Cohen and Eric Rhenman, Carnegie Institute of Technology and The Business Research Institute of Stockholm School of Economics*
*MANAGEMENT SCIENCE, January 1961; pages 131-166*

Some of the management games which have been developed, as a result of military war games are: American Management Association game, developed in 1956; IBM Management Decision-Making Laboratory; UCLA Executive Game No. 2; and games developed by Carnegie Institute of Technology, Westinghouse Electric Corporation, University of Washington, Pillsbury Mills, University of Oklahoma, and Indiana University. The AMA game treats the financial picture with extreme simplicity--all expenditures are treated as current cash flows. The IBM adds complexity on the marketing side. In the UCLA game, the playing firms may, in effect, borrow money.

One of the most complex games is the one developed by Carnegie Tech. This game mirrors more realistically than earlier games the problems of running a company. To produce a desired amount of finished goods, players in the Carnegie game must not only request it, but they must also coordinate maintenance, overtime policies, hiring policies, raw materials purchasing, and other variables that affect the extent to which scheduled production and actual output coincide. Players have to record between 100 and 300 decisions for every "month" of simulated play. To make these decisions, they get on a regular basis or through special purchase several hundred pieces of information about their own performance and about their relations with competitors, suppliers, customers, and financial institutions.

"In the Carnegie Tech game, as in most top management games, the ostensible object of play is fairly vague. The participants are not told that they are supposed to maximize profits, maximize sales, maximize total assets, or maximize anything at all. Each company must decide for itself what goals, both short run and long run, are appropriate to them in the light of what they know of the business world. Furthermore, no simple standards are established by which the administrators of such a game can determine which firm has done best. Some of the most fruitful discussions in the feedback sessions following play of these games revolve about the choice of criteria for 'winning the game.'"

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*Games for specific problems*

A number of management games have been developed which focus specifically on problems of decision-making as seen in one particular functional area. The AMA "Materials Management Simulation" is one of this type of game. Others are Tulane University's Production-Manpower Decision Game; General Electric's "Dispatch Game" and "Marketing Strategy Simulation Exercise"; University of Pennsylvania's "Smart" and "Inventrol"; Kroger's "Supermarket Decision Simulator"; Boeing Airplane Company's "Operation Feedback on Management Controls"; Burroughs' "Steps"; and several non-computer functional business games published by Greene and Sisson.

Most games have six characteristics in common: 1) feedback of results, 2) expression of the environment's characteristics in mathematical or logical relations (some of these are completely made known to the players--others made known only in a vague qualitative manner); 3) environment is represented by a computer, either human or machine which offers passive interpretation of the environment's response to the actions of the players; 4) interaction between players; 5) interaction between functional groups within a "company"; 6) simplicity, which results both from our lack of knowledge of how the world really is and from desire to keep the games "playable."

*Teaching by games in university and industry*

Games are being used widely as a teaching device, both by universities and by industry as a part of executive training courses. Not only are the games fun, but it is felt that important aspects of an educational program can be taught much more effectively through the use of management games than in any other way. However, critics say that it sometimes seems doubtful that the proponents of games have been clear about what they were trying to accomplish. But as knowledge of games is increased through continued experience in designing and playing them, this knowledge should be formalized so that we may know what advantages games of various types might have when compared with other teaching devices, and understand how to design a game which will possess certain desired properties in use.

Business games have some advantages over conventional business case studies. In the case study, there is seldom a chance to try a problem more than once. Also, usually it is impossible for students to get any direct feedback on the consequences of the decisions they have made. Business games can overcome these two limitations. Uncertainty, an important environmental characteristic of business, can be convincingly illustrated in a management game. These games help the students get used to exploring their environment. The total task situation which a business game imposes upon students provides an opportunity for learning and reinforcing a variety of analytical tools. Psychological and organizational interactions are important in playing games. Institutional facts can be taught. The players' attention is focused on the importance of establishing policies and on making long-range plans.

However, some cautions are given in the use of games as teaching devices. No empirical evidence has been amassed which proves either that these concepts can actually be taught by the use of

management games or that they can be taught more effectively by games than in some other ways. They are quite expensive, in capital costs, out-of-pocket costs of running the game, and the opportunity cost to the participants in that while they are playing the game they are prevented from using that time in any other way. While games seem to teach certain important concepts, the question remains whether or not they are an economical use of time. In addition, no game yet developed includes all of the kinds of problems that managers have to face, the problems of information gathering are not well handled in any game, there is a danger that the participants will feel too strongly that they really know how to run a business, and it is important that games be realistically valid about the facts they teach about the world.

*Business games need improvement*

It is suggested that business games be improved through combining their best points with the best points of the dynamic business case, described as a case study in which the group is confronted with a realistic problem described in text as in the conventional case study, but in which the situation is dynamic. The amount of information given to the group depends upon its own actions. The environment changes as the group works with the case, to some extent reflecting a feedback of the group's actions. It may include some role playing, and its development requires a great number of man-hours of work by various specialists, plus a talented case author. The dynamic business game would not require that all the rules of the game and the whole environment be specified in a complete computer program and that all the rules of the game be presented to the players at the start of the game. "Free" and "non-structured" elements would be introduced, and the players' creativity is challenged by their being informed at the start of play that all financing possibilities which generally exist for a firm are also open to them in the game. Periodically, the firms represented in the game are confronted with the necessity for negotiating a new contract with their labor unions. Public relations problems are introduced during the play through information about strikes, rapid price changes, excessive profits, and other circumstances. At a certain stage in the play the players are warned about the risk of an impending change in the business cycle, after which they would be allowed to purchase whatever information they want.

*Realistic factors can be added*

Feedback would be continuous so that the teams could make decisions at any time which consist of policies rather than specific actions. The dynamic business game would also allow the teams to interact among each other, conducting face-to-face negotiations with each other on such things as selling of raw materials, cross-licensing of new products, sharing warehouse space, borrowing funds, merger, etc. It is also proposed that the players' manual for a game should allow the teams free reign in decisions on research and development.

Management games can be useful as a research tool for training purposes; for use in discovering optimal patterns of business behavior; in economic research relating to the behavior theory of firm; in organization theory; and in psychological problem solving.

## SIMULATION: A NEW TOOL FOR MANAGEMENT EDUCATION

*William H. Fichthorn, Ohio University, Athens, Ohio*
*SYSTEMS AND PROCEDURES, January/February, 1961; pages 8-17*

The advantages of simulation as a teaching device in business management courses are: 1) the involvement and enthusiasm they evoke in participants; 2) the relatively low cost of the game as a training device; 3) the ability to compress many decision situations into a short space of time; 4) participation in simulations makes participants more receptive to absorbing information on decision-making than attendance at lectures or case discussion.

*Limitations on using simulation*

Some examples of management games designed by companies and by universities are given, along with one book devoted to a variety of decision games. The Ohio University management simulation game is described in detail. Some limitations on the use of simulation are given also: 1) the present state of simulation does not permit including qualitative influences on the effectiveness of decisions; 2) simplification necessarily eliminates some real-world decisions which should be made; 3) most games provide for the marketing of only one product; 4) participants are likely to neglect other parts of the course through involvement in the simulation; 5) at present, simulation designers and instructors do not know what participants learn. The decisions, parameters, and feed-back information may be subtly biased to such an extent that the participant gets a distorted concept of decision-making in the real world of business.

Since simulations are presently so crude, it is doubtful that they should be used to evaluate management personnel. Also, it is questionable whether simulations can be used to predict with accuracy the results of following alternative courses of action. However, being aware of the limitations, the instructor can use simulations as an effective teaching tool if he uses them properly and in the right situation.

## DECISION MODELS FOR INVENTORY MANAGEMENT

*Robert B. Fetter and Winston C. Dalleck*
*Published by Richard D. Irwin, Inc. 1961. $5.75*

This small book, just over a hundred pages, is concerned with scientific inventory control. It is divided into three sections: Inventory Decision Models, Input Data, and Numerical Examples. In the third section, a short description of inventory control using a computer is given. The book stresses a way of thinking about inventory problems, rather than presenting a set of solutions. The authors hope to enable persons concerned with inventory management to solve their own inventory problems through an understanding of the eccnomics of inventory situations.

# General Information

## SOME PROBLEMS AND APPROACHES TO AUTOMATION OF MEDICAL DIAGNOSIS

*Philip A. Smith, System Development Corporation, Santa Monica, Calif.*
*BEHAVIORAL SCIENCE, January 1961; pages 88-91*

"Obtaining a medical history and recording physical symptoms is a complex judgmental process rather than a simple enumeration and tabulation of discrete, manifest, informational items....Clinical experience shows also that patients differ markedly in the degree to which they feel free to talk or are able to describe their symptoms. Thus, the determination of what represents factual raw data for diagnosis is...a formidable problem." However, research in data-gathering physiological measures is progressing. When great quantities of data are gathered, computer processing is necessary.

With so much of the data being of the subjective type, a method for processing this automatically must be found. It is suggested that clinical observation and interview data be routed through a judge. Assuming judges agree, the data can then be processed by a computer. Another method would be to use a check list of signs or indicators which are checked against a statistical norm. This approach has led to interest in automating the interpretation of diagnostic inventories. However, this procedure would be only as good as the test items on which it is based, and it is dependent upon the willingness of the subject to respond. Also, it is dependent upon the comparison data and "on the very meaning and utility of diagnosis itself."

Other applications for computers in the medical field are suggested:

1. Simulation of the actual cognitive processes of a medical diagnostician.
2. Administration of anesthesia.
3. World-wide public health information system.
4. Hospital records and public health data.
5. Scientific use of computers in large-scale research projects.
6. Pilot systems for direct multivariate data collection, conversion, diagnostic analysis, and display to the individual physician.
7. Rapid-access computer-stored catalogs of pharmaceutical information.
8. Clinical trials of the usefulness of promising drugs.
9. Hospital administration.

## DIGITAL COMMUNICATIONS SYSTEMS

*DATA PROCESSING (USA), February 1961; pages 15-20*

An analysis of communications requirements should include system design, need for accuracy, and system balance; and it must be remembered that the ultimate destination of data is the point at which the information is translated into executive action.

"The selection of the proper data originating device must be based on the available operating time and the volume of characters to be transmitted. These parameters are used to derive the transmission rate required to move the data from point of origin to the central site." Consideration must also be given to the data rate capacity of the carrier. The data rate has economic significance in several ways:

1. Random dialed toll calls may be practical if the data rate is sufficiently high to allow all the data to be transmitted before the breakeven point is reached between leased lines and random toll calls. Also, if lines are leased for administrative crosstalk, unused time may be profitably used for "free" data transmission.

2. Since the rate structure is based on distance and time, the time to transmit the data should be reduced as the distance increases. It is generally cheaper to use high speed transmission for long distances.

*Input data accuracy is crucial*

The accuracy of the system is a function of operator performance, equipment performance, and line performance. There is a danger that data improperly entered will continue to disrupt the operation until manual or automatic crosschecking uncovers the error. Thus, some sort of checking provision must be made in the system.

Data may be received in batched form or in random sequence, and the latter, real-time system, is the more expensive. "The cost of real time input connected to a delayed central processing data gathering center is money down the drain. If the advantage of real time data origination warrants the cost then the real time process must be preserved throughout the system for maximum return on input equipment investment." The number of input trunks, volume of data of each trunk and the requirement for a specific processing method will tend to specify the central processor and auxiliary storage devices. "The processing method (delayed vs. real time) will dictate the balance between the storage requirements and memory cycle speed."

Output data is generally exception data relayed for executive action. Therefore, output devices should be selected for this specific purpose. A line printer may be needed one place, but a display tube may be more appropriate elsewhere. "It should be also be recognized, however, that a good communications system is more than just point-point transmission. Not always will the data flow from point of origin

to computer site or vice versa. Suppose a complex of computers exists and the data must flow from one of perhaps five sites to any of the other four. Suppose, further, that these sites are not always attended at the same time. Further, consider that some of the messages may have multiple addresses and be of different priorities. This imposes an entirely new set of considerations on the data communications problem. The concepts of message routing, intermediate storage and switching are introduced. A further sophistication is that of unattended operation at the terminal points."

The next major development in input equipment will be in optical character recognition. As yet this equipment is expensive, must be limited to centralized use. "Thus, today's two most important developments in electronic data processing are in direct opposition--optical character recognition pointing in the direction of manual transportation to a central location and data communications leading to a direct system input and output at the point of transaction."

When optical equipment becomes less expensive, data preparation will be a field operation using ordinary typewriters. The data will be read optically as direct input to a communications link.

## AUDITING UNDER AUTOMATION

*Morris A. Engleman, Bankers Trust Company, New York City*
*AUDITGRAM, March 1961; pages 8-13*

Correct systems design will assure the auditor of an adequate control operation in an EDP system. The systems design should establish time cycles for posting records and for input and output. At the close of any of these time cycles it must be possible to perform an audit. A reproduction of the magnetic tapes, a printout of control information, a reproduction of the daily transaction journal, or a carbon copy or microfilm of statements may be used. Output results should be printed out in hard copy in the form of daily transaction listings, journals, or microfilm that provides an adequate audit trail.

Auditors must become reconciled to the disappearance of the familiar visual or historical records. They must be satisfied with the reliability of the system's control procedures. Some of the controls are built in by the manufacturer. Others are included in the program, and the auditor must help in providing for these. In addition, the auditor must be concerned with the division of responsibilities within the automation department. The programs must contain a safeguard against the operator's changing the program at the console. Information introduced at the console should be printed out, and any changes should be recorded in a log. Changes in a program should be approved by the auditor. He should have test decks which may be used randomly to test a program. Librarians should release tapes only to authorized personnel. Ideal storage of tapes must be provided to keep the information from deteriorating. The method used by Bankers Trust to set up their EDP system concludes the article.

## AN AUDITOR'S EXPERIENCE WITH ELECTRONICS

*Kenneth G. Cadematori, Price Waterhouse & Co.*
*THE INTERNAL AUDITOR, Spring 1961; pages 9-22*

The internal auditor can usually find in the computer-produced printouts for executive information the information formerly found in a number of listings and card files. Thus, the auditing procedure is not made more difficult by the EDP system. Although processing wipes out prior information, leaving no visible record, the auditor has complete printouts of each day's transactions for his use ((if deemed desirable and pre-planned)), and the information the internal auditor needs is generally that also needed by management. Data needed by the auditor can be provided for in programing. Responsibility for accuracy should be placed upon the data originator.

The ability of EDP systems to perform management control functions with visible evidence of review or human authorization are posing new problems to the internal auditor, which he must solve by developing new techniques appropriate for computing systems.

## THE INFLUENCE OF EDP ON INTERNAL CONTROL

*Robert J. Fitzpatrick, Bellarmine College, Louisville, Kentucky*
*THE CONTROLLER, March 1961; pages 123-126, 150*

The separation-of-duties principle may be applied to an EDP system by having the data-originating groups such as the payroll and sales departments establish their own controls over data before releasing it for processing. In addition, the various personnel in the center may, through their duties, provide checks upon each other. Also, the computer may be provided with audit controls, such as: programed controls, checks in central processing unit, checks in peripheral equipment.

Programed controls are those which allow the operation to be performed in two different ways at some point in the program, with a comparison of the results. The instructions for these controls must be included in the program when it is originally set up. Programed controls include such things as record counts, hash totals, proof figures, reverse multiplication, limit check, cross footing balance totals, check points, self-checking numbers, sequence checks, label checks. Each of these is discussed in the article. Companies have found that it is wise to have errors printed out for later correction rather than to stop the processing to correct an error.

Built-in controls in the equipment include parity bit, double-track recording and reading, duplicate circuitry and double arithmetic. Checks in peripheral equipment include verifying units for input, visual examination, two reading stations for checking card input, check for card output, and check for printed output.

# Programing and Operation

## MAINTAINING A COMPLEX ELECTRONIC INSTALLATION

*Thomas R. Darmody, The M. & T. Company, Philadelphia*
*JOURNAL OF MACHINE ACCOUNTING, March 1961; pages 21-25*

Electronic systems must be efficiently maintained. The two general categories of maintenance are preventive and corrective. But even before maintenance programs can be set up, there are some decisions to be made. If the system is leased, it may be expedient for the lessee to contract for maintenance from the manufacturer. If it is purchased, he may still contract for maintenance from the manufacturer. However, if he has equipment from several different companies, he will find it wise and economical to contract for maintenance from a specialist in equipment servicing. The maintenance program should be ready to go into service the day the equipment begins to operate.

*Pre-plan maintenance schedule*

Unless the equipment has been designed at a 100% or more redundancy level, it will have to be scheduled for maintenance down time. Maintenance procedures are customarily set up on interlocking and complementary schedules on daily, weekly, monthly and quarterly bases. The manufacturer's recommendations should be followed until experience has provided the foundation for independent action to meet local requirements. Daily maintenance must be done in the half hour or hour before the day's computing operation begins, or at the turnover of a shift. A record of intermittent faults must be kept to help the maintenance man during maintenance time. His own record of corrective maintenance performed during the preceding shifts also serves as a guide.

Weekly maintenance periods are a more comprehensive version of the daily checkout. Sometimes it covers a complete shift. Sometimes some of the quarterly or annual maintenance procedures are performed at this time. Monthly, quarterly, or annual schedules are devoted to overhaul of subsystems, installation of manufacturer modification and change orders, and major procedures such as cleaning the entire system, lubricating mechanical parts, scheduled replacement of parts whose lifetime have run out, and sometimes wholesale replacement of tubes or other replaceable components.

*Omnibus routines daily and weekly*

Maintenance procedures include sequence checks, logical checks, and operational routines. An omnibus routine is a computer program that uses every portion of the system circuitry, usually in the most demanding possible routines, and relies on built-in parity checks and final answers which are known in advance, to determine any malfunction of circuits or subsystems. Most large computer systems are tested with omnibus routines weekly, and simplified versions are used daily. The marginal test is one in which the omnibus routine is run with the voltages at marginal level, to reveal any malfunction of marginal parts.

Cleanliness is a key to good maintenance. Mechanical parts are critical and must be carefully attended to. If trouble develops during production runs, good communications with the maintenance department is vital. Technicians should be standing by at all times, and schedules may be arranged so that portions of the system which are not in use may be serviced during this stand-by time. The amounts of components in stock depend on experience of need. However, most companies willingly pass along advice to new users of similar equipment. Good test equipment is an absolute necessity, and authority for the service supervisor to purchase supplies and specify delivery is essential.

"The time lost by any complex electronic system is so expensive that good maintenance procedures are economically imperative. In industrial controls, the need is even greater, because the safety of the whole plant may depend on the proper functioning of the control system."

"Good maintenance should hold lost time due to unscheduled corrective maintenance and troubleshooting to less than five percent."

## BATTLE OF THE PSEUDOS

*COMPUTING NEWS, January 15, 1961; pages 11, 12*

In the early days of the computer game, "the hardware had it, saleswise." Now, however, the program is the big selling point. "...it doesn't matter much how you build your machine any more. It only matters how you program it. This is interesting, for it seems to be producing an effect opposite to that predicted by those minor prophets who were able to state that 'Programmers are rapidly working themselves out of their jobs' at the time the first one-lung compilers began to sit up and fly. There are plenty of jobs for programmers today, and more and more of them are with the computer makers.... In short, the work of preparing a computer to do work has somehow become big business. Like all big businesses, it has its problems. Like most such problems, they can be solved economically using a big electronic computer. Hence we see that the big business of planning the work of electronic data processing constitutes an area in which we must surely apply the principles of electronic data processing, thereby creating a whole new area of problems large enough so that we should surely apply electronic data processing, creating in turn another area manifestly large enough so that we should consider..."

## PROGRAMMING FOR DIGITAL COMPUTERS

*J. F. Davison*
*Business Publications Ltd. 1961. 35s (about $3.25)*

Elementary programing is presented in the familiar fashion by invention of an imaginary computer, and is carried through to an explanation of interpretive routines. There is no bibliography or index included.

# Systems Design

## ELECTRONIC DATA-PROCESSING FOR THE LINE OFFICIAL

*Published by Remington Rand Univac*

Here is an interesting and valuable manual for management use in training line officials and computer systems designers to work together in creating an efficient data processing system. The manual was first used by the Chesapeake and Ohio Railway Company.

"The development and operation of this new data-processing system is fundamentally the responsibility of the line official. He is the man most familiar with the department's operations; he is the man who knows best what the demands on the old system are, and what the demands on the new system will be. But the line official cannot be expected to carry out this responsibility alone. To aid him in this work he is provided with a staff of system designers.... The purpose of this manual is to provide the line official with the tools necessary to obtain from his system designers the most efficient, inexpensive and productive data-processing system possible."

The system designer will be unfamiliar with the details of the procedures to be computerized and by the language the line personnel use to describe the procedures. Therefore, it is important that the line official communicate with the system designer in the system designer's language. The manual describes some procedures for effecting communication between the two, describes those parts of the system which should be reviewed by the line official, and describes the installation procedures for the computer system. The design and installation consists of seven steps: survey, system investigation, system design, programing, filemaking, preparation of clerical procedures, program testing. A chapter is devoted to each of these steps.

## SYSTEM SIMPLIFICATION

*W. Sidney Taylor, U.S. Air Force*
*THE JOURNAL OF INDUSTRIAL ENGINEERING, January-February 1961; pages 3-10*

System analysis has become an important management technique in the design of an automated system, because of the complexity of business organizations. System Simplification "constitutes a synthesis of principles and techniques borrowed from Operations Research, Industrial Engineering, and Systems Engineering. It is equally applicable in improving the design or operation of weapon, logistic, product or administrative type systems. As a tool, it is oriented toward im-

proving executive skills and comprehension at system levels....preliminary to developing management or product improvements, conducting reorganizations, installing automation or designing automatic data processing systems."

*The simple approach is best*

System Simplification aims to simplify total business objectives, plans, policies, operations, controls, etc. It emphasizes the development of executive skills at conceptual levels, and is a program of executive education oriented toward improved knowledge and comprehension of the phenomenon of large scale man-machine operations. "In designing new and more effective systems....the systems executive or engineer must be simplicity-minded. He must continually orient himself toward doing the job with purposeful objectives, least number of components, uncluttered organization and control structure, and the minimum investment, expenditure, or risk of resources. Underlying this assumption, is the fact that simplicity in itself tends to improve other system characteristics such as economy, efficiency, control, accuracy, reliability, maintainability, producibility, flexibility, etc."

*Documentation blends into simulation*

The techniques used are documentation, simulation, and interrogation. "In order to comprehend, let alone improve, a large scale system involving thousands of 'man-machine-environment' relationships, it is necessary to portray or document at least the primary objectives, structure, components, workloads and resources involved....Documentation will vary with the nature of the system. Among the techniques employed are: organization and function charts; manning or position charts; cost distribution charts; workload or workflow charts; production process charts; plant or office layout charts; information or data flow charts; performance or profit graphs, etc."

Some examples of documentation are: the Air Force Panel Rooms, in which wall charts present a panoramic picture of worldwide weapon system operations; the DuPont chart room with significant data and trend concerning the corporation's total operation is contained on 400 framed charts suspended from overhead tracks; United Air Lines' Denver control room, giving a pictorial perspective of total system operations including daily airline traffic and corporation profits. A unique psychological by-product of system documentation is its tendency to induce new perspective, ideas and improvements at top management levels.

An indefinite line marks the division between documentation and simulation. System simulation or model building reflects the organization in quantitative and dynamic form. Performance can be measured and it is possible to manipulate, test, and price improvements on paper without risk or interference in actual operations. Every manager has at least four models which simulate or represent the operations of his business or enterprise. These are: 1) Economic: the accounting system, profit and loss statement, etc.; 2) Social: the organization chart; 3) Physical: the plant, machines, work layout, etc.; 4) Information system, the keystone to effective integration, control and feedback for total business operations.

System interrogation suggests that the right question at total system level can often uncover dramatic improvement potential. It may take the form of a systems survey or management audit. It involves orderly inquiry into the objectives, plans and operations of the total business or enterprise. Interrogation complements documentation and simulation by providing a panoramic review of those elements in the system which can not be easily portrayed or quantified; business objectives, policies, plans, executive motivations, competitive strategy, etc. The American Institute of Management in New York has developed a management audit checklist which includes a series of 300 questions designed to appraise the effectiveness of a large organization.

Ability to ask big questions, think and innovate has become fundamental in the design and operation of large scale systems.

## SYSTEMS ENGINEERING

*IBM DATA PROCESSING INFORMATION, January 25, 1961*

Systems engineers need a fine degree of know-how, perspective, and judgment, plus a certain talent--"the ability to see the whole forest while sitting on a limb of one of its trees." The systems approach is a method of first overviewing the business system as an entity rather than as the collection of elements that comprise it. After collecting the known facts, the systems engineer may want to add information about future requirements, developed through forecasts and carefully-arrived-at predictions. System simulation may help here.

Since the scientific method needed in system engineering combines detached competence with enthusiastic creativity, a team effort is usually necessary to provide both qualities. The basic system study is likely to take longer than the final solutions phase. After the system has been structured, simulated and proved, final decisions can be made about equipment to perform the job. Systems engineering interest must continue, however, since a system does not remain static. There will be continuing need for modification, improvement, and enlargement.

# Information Retrieval

## CITATION INDEXES FOR SCIENCE

*Eugene Garfield, Institute of Scientific Information, Philadelphia, Pa.*
*SCIENCE, July 15, 1955; pages 108-111*

A citation index is one which lists references to papers made by authors in their own papers within the text, as footnotes, or in bibliographies. It is suggested that such an index "can eliminate the uncritical citation of fraudulent, incomplete, or obsolete data by making it possible for the conscientious scholar to be aware of criticisms of earlier papers." Also, "by virtue of its different construction, it tends to bring together material that would never be collated by the usual subject indexing."

*An index to references in literature*

A basic difficulty in subject indexing is to anticipate the number of possible approaches a searcher may require. Classification is not the answer. "What seems to be needed...in addition to better and more comprehensive indexes, alphabetical and classified, are new types of bibliographic tools that can help to span the gap between the subject approach of those who create documents--that is, authors--and the subject approach of the scientist who seeks information. Since 1873 the legal profession has been provided with an invaluable research tool known as Shepard's Citations....a listing of individual American court cases, each case being followed by a complete history, written in a simple code. Under each case is given a record of the publications that have referred to the case, the other court decisions that have affected the case, and any other references that may be of value to the lawyer. This type of listing is particularly important to the lawyer, because, in law, much is based on precedent."

A citation index to science would have the following main characteristics. "First there would be a complete alphabetic listing of all periodicals covered, in addition to the code number for each periodical ....The main portion of the citation index would list in straight numerical order the code numbers for all the articles covered. Under each code number, for example, 3001-6789, there would be listed other code numbers representing articles that had referred to the article in question, together with an indication of whether the citing source was an original article, review, abstract, review article, patent, or translation, and so forth. In effect, the system would provide a complete listing, for the publications covered, of all the original articles that had referred to the article in question."

The listings would provide each scientist with a kind of individual clipping service. "It is also possible that the individual scientist thus might become aware of implications in his studies that he was not aware of before."

*Begin in a small way*

The enormous size of the task of building a citation index to cover all publications should not prevent a start from being made. In fact, coverage could be limited to those periodicals covered by one of the leading index services. "It would be necessary to consider all the pros and cons in a selective approach and then to determine the possible utility of such a tool." The ultimate success of a citation index would depend on many factors. "For example, if each periodical would assign unique code numbers to the articles published, it would be possible for authors to list these numbers in their bibliographies and, thus, to save the work of coding on the part of the citation index staff."

Computers could be used to process large volumes of the data. Once the coding is done the compilation is quite mechanical.

"Were an army of indexers available, it is still doubtful that the proper subject indexing could be made. Over the years changes in terminology take place, that vitiate the usefulness of a standard subject index. To a certain extent, this is overcome through the citation approach, for the author who has made reference to a paper 40 or 50 years old has interpreted the terminology for us. By using authors' references in compiling the citation index, we are in reality utilizing an army of indexers, for every time an author makes a reference he is in effect indexing that work from his point of view. This is especially true of review articles where each statement, with the following reference, resembles an index entry, superimposed upon which is the function of critical appraisal and interpretation."

*Papers of significance will stand out in the index*

In the case of a highly significant article, "the citation index has a quantitative value, for it may help the historian to measure the influence of the article--that is, its 'impact factor.' With regard to a less significant work, one would suspect that the bibliographic advantages might be increased, because the scientist or librarian would be provided with references not to be found in conventional indexes."

The farther away you get from the immediate subject area of the main article, the fewer the references--yet these may be the most useful of all, for the cross-fertilization of subject fields is one of the most important problems in science literature.

The citation index may be compiled in the following manner:

1. Select the particular group of periodicals to be covered.
2. Select the period to be covered.
3. Assign to each coder a group of articles in a particular journal.
4. Number the articles in the journal in ascending order.
5. Assign to each periodical the proper code--for example, the number given in the World List might be used.

6. The coder prepares 3x5 cards for each citation made in an article. Each card would contain the code number for the citing article, the code number for each article cited, and a classification of the citing article as an original contribution, review article, abstract, etc.

7. Sort the cards by the code numbers for the items cited. This would produce a group of cards for each cited article. These would then be sorted by code numbers for the citing articles.

8. Prepare the cards for the printer.

Relatively unskilled persons can be used for the coding and filing, if professional supervision is also available for exercising judgment in questionable areas.

"If the system were adopted, then in the future, every author ought to be required to include the serial number of each item he referred to, so as to facilitate not only the compilation of citation indexes but also other operations such as requests for reprints.... The new bibliographic tool, like others that already exist, is just a starting point in literature research. It will help in many ways, but one should not expect it to solve all our problems."

## INFORMATIONAL RETRIEVAL AND MACHINE TRANSLATION

*Edited by Allen Kent, Western Reserve University*
*Published by Interscience Publishers, 1960. Part I: $23; Part II: $25*

This is Volume 3 of the series "Advances in Documentation and Library Science," edited under the direction of Jesse H. Shera of the Center for Documentation and Communication Research of Western Reserve University. ((Volumes I and II were reviewed in DPD February 1958, page 4 (Idea Finder page 402) and April 1958, page 5 (Idea Finder page 403).))

This two-part work presents the papers and discussions of the International Conference for Standards on a Common Language for Machine Searching and Translation held jointly by Western Reserve University and the Rand Development Corporation in 1959. The emphasis in Part I is on machine literature searching; in Part II on the problems of machine translation and the search for a common machine language. A long chapter by the editor presents an analytical review of the subject.

# Comment

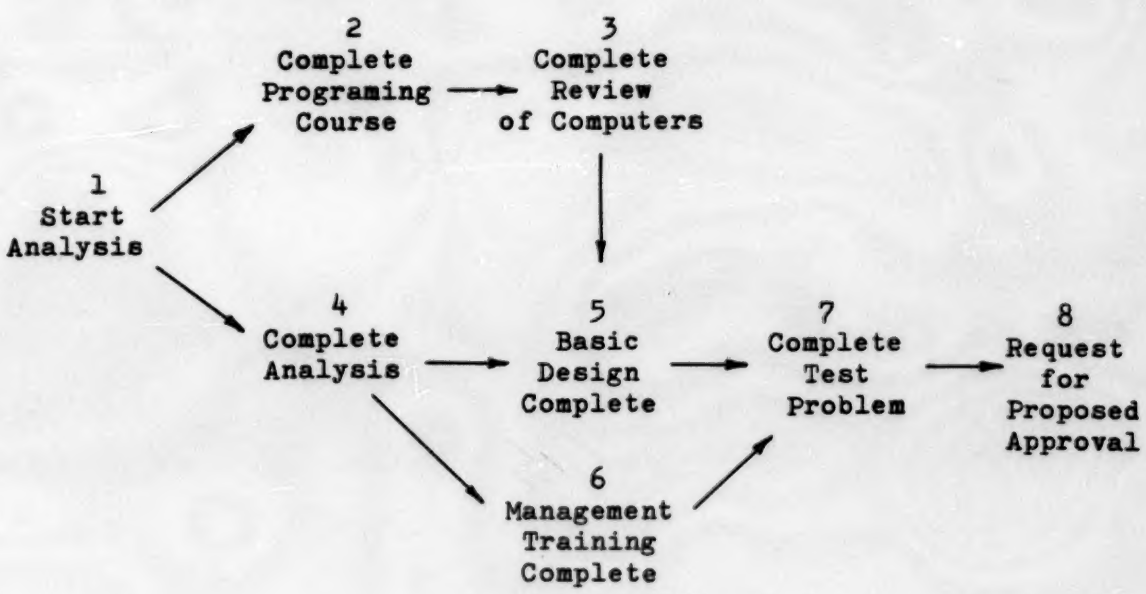
## PERT

The problem of controlling a programing, engineering or design effort has long bothered management. PERT (Program Evaluation Review Technique)[1] was designed for the Navy's Polaris program to improve performance in meeting schedules on such efforts. "Critical Path Scheduling"[2] is a similar technique. It is of interest to EDP people for two reasons:

- The technique is made possible for large projects by the existence of computers to perform detailed computations

- It can be helpful in managing EDP system design and programing efforts.

The technique works like this: The overall job is broken down into tasks of a size for which good time estimates can be made (say, a few weeks each). The sequence of these tasks is then portrayed as a network such as this:




The nodes are the events which denote progress: completion of an activity, approval, a key decision. The lines represent tasks; 4-5 is the process of doing a basic system design. Note that the interrelationship or sequence of tasks is clearly shown.

Next an estimate is obtained for the time to complete each task (the method actually obtains estimates of the mean time and variance).

The computational procedure then develops reports which show: expected time to reach each event, the probability of reaching an event (particularly the final one) by a given due date, and the critical path. This path is the sequence of tasks which can "slip" the least in schedule and still make a given final due date. The permissible amount of slippage is called slack (which can be negative--meaning time must be made up to be on schedule).

Knowing the critical tasks, management can reallocate effort, expedite, etc., to improve chances of meeting scheduled due dates.

In the above example (ignoring the useful probabilistic data), if the task time estimates are:

| TASK | TIME ESTIMATE (Weeks) |
|---|---|
| 1-2 | 2 |
| 2-3 | 4 |
| 3-5 | 2 |
| 1-4 | 6 |
| 4-5 | 8 |
| 5-7 | 5 |
| 4-6 | 3 |
| 6-7 | 1 |
| 7-8 | 2 |

and the final due time for event 8 is 20 weeks after start, then the results are these:

| EVENT | EARLIEST COMPLETION | LATEST COMPLETION | SLACK |
|---|---|---|---|
| 1 | (assumed to be complete) | | |
| 2 | 2 | 7 | +5 |
| 3 | 4 | 11 | +7 |
| 4 | 6 | 5 | -1 |
| 5 | 14 | 13 | -1 |
| 6 | 9 | 17 | +8 |
| 7 | 19 | 18 | -1 |
| 8 | 21 | 20 | -1 |

The critical path is obviously 1 - 4 - 5 - 7 - 8, along which one week must be eliminated to meet the schedule.

If your company has research, development, engineering or construction rebuilding, repair or cleaning jobs, you should investigate this technique. And especially, if you are in (or are about to start) an EDP system design and programing effort, by all means investigate PERT techniques to schedule the activities. It will provide these benefits:

- The probability of performing on schedule will be increased
- Project management will have a good tool (the network) for communicating its plans
- Potential slippage will be clearly indicated and the critical tasks isolated.

SUGGESTED READING


1. D.G. Malcolm, J.H. Roseboom, C.E. Clark, W. Fazar; "Application of a Technique for Research and Development Program Evaluation," OPERATIONS RESEARCH, Oct. 1959.
2. J.R. Kelley, M.R. Walker; "Critical Path Planning and Scheduling," PROCEEDINGS OF E.J.C.C., 1959.
3. P.J. Klass; "PERT/PEP Management Tool Grows," AVIATION WEEK, Nov. 28, 1960.
4. R.J. Freeman; "A Generalized Network Approach to Project Management," IRE TRANSACTIONS ON ENGINEERING MANAGEMENT, Sept. 1960.
5. D.R. Fulkerson; "A Network Flow Computation for Project Cost Curves," MANAGEMENT SCIENCE, Jan. 1961, pages 167-178. This article discusses an advanced technique for including costs.


## Training

PERT/PEP Seminars, sponsored by Management Control Systems Inc.

| | | | |
|---|---|---|---|
| Date: | May 15-19, 1961 | Date: | June 5-9, 1961 |
| Place: | Washington, D.C. | Place: | Dayton, Ohio |
| Fee: | $375 per person, including materials and lunch | | |
| Information: | Management Control Systems Inc., 1 Story St., Cambridge 38, Mass. | | |

Advanced Techniques of Programming Digital Systems

| | |
|---|---|
| Date: | May 20-June 10, 1961 |
| Place: | University of California at Los Angeles |
| Fee: | $175 |
| Information: | University Extension, University of California, Los Angeles 24, California |

University of Michigan, College of Engineering Summer Conferences: courses are offered in operations research, management sciences, and advanced data processing. For information, write to R. E. Carroll, 126 West Engineering Building, University of Michigan, Ann Arbor, Michigan.

PERT/PEP Training Course, sponsored by Operations Research Incorporated

| | | | |
|---|---|---|---|
| Date: | June 5-9, 1961<br>July 10-14, 1961 | Place: | Silver Spring, Maryland |
| Date: | May 15-19, 1961<br>June 26-30, 1961<br>July 24-28, 1961 | Place: | Santa Monica, California |
| Fee: | $290 per person, including materials | | |
| Information: | Operations Research Incorporated, 225 Santa Monica Blvd., Santa Monica, California | | |

5th Annual UCLA Summer Executive Program

Date: June 11-30, 1961
Place: Lake Arrowhead, California (University of California Conference Center)
Fee: $650
Information: Dr. Fred E. Case, Graduate School of Business Administration, University of California, Los Angeles 24, California

Electronic Data Processing Seminar for Bankers, sponsored by NABAC, The Association for Bank Audit, Control and Operation

Date: June 12-15, 1961
Place: Chicago, Ill. (Sheraton Towers Hotel)
Information: NABAC, 38 S. Dearborn St., Chicago 3, Illinois

Industrial Engineering Seminars

Date: June 13-16, 1961
Place: Department of Industrial and Engineering Administration, Sibley School of Mechanical Engineering, Cornell University
For whom: Operating management personnel in line supervision and staff positions in industrial engineering, production engineering, engineering administration, operations research, research and development, quality control, production control, cost control, materials management, purchasing, data processing, and the controller's function.
Information: J. W. Gavett, Seminars Coordinator, Department of Industrial and Engineering Administration, Upson Hall, Cornell University, Ithaca, New York

Seminars in Industrial Engineering

Date: June 13-16, 1961
Place: Cornell University
Information: J. W. Gavett, Upson Hall, Cornell University, Ithaca, New York

Systems and Procedures Course, sponsored by American Management Association

Date: Unit I: Sept. 11-15, 1961
Unit II: Oct. 9-13, 1961
Unit III: Nov. 27-Dec. 1, 1961
Place: AMA Academy, Saranac Lake, New York
Fee: $775 (AMA members: $675)
Information: Hollis Wyman, Course Director, AMA Academy, Saranac Lake, New York

Engineering Executive Program, presented by University of California at Los Angeles

Date: Beginning September, 1961
Place: University of California at Los Angeles, California
Fee: $350 for each semester
Requirements: Applicants must meet the acceptance standards of the Graduate Division of UCLA, and must have at least 5 years full time industrial experience
Deadline: Applications must be submitted by March 1, 1961
The Engineering Executive Program, Dept. of Engineering, Room 4173C Engineering Bldg. Unit I, University of California, Los Angeles 24, California

Operations Research Development Program

Date: September 18, 1961 - January 26, 1962
Place: Case Institute of Technology
Fee: $1000
For whom: Intensive program at the graduate level for qualified scientists and engineers with industrial experience. Successful completion of the program is recognized by the award of a Certificate in Operations Research.
Information: Professor Russell L. Ackoff, Case Institute of Technology, University Circle, Cleveland 6, Ohio

# Meetings

NOMA International Conference and Office Exposition

Date: May 7-11, 1961
Place: St. Louis, Missouri (Sheraton-Jefferson Hotel and Kiel Auditorium)
Information: W. H. Latham, National Office Management Association, Willow Grove, Pennsylvania

Western Joint Computer Conference

Date: May 9-11, 1961
Place: Los Angeles, California (Ambassador Hotel)

AIIE Annual Conference

Date: May 11, 12, 1961
Place: Detroit, Michigan (Sheraton-Cadillac Hotel)
Information: A. Patrick, Program Chairman, 28093 Wildwood Trail, Farmington, Michigan

Symposium of the Federal Government Accountants Association

Date: May 18, 20, 1961
Place: Washington, D. C. (Hotel Shoreham)
Theme: "Changing Dimensions of Financial Management"
Information: Federal Government Accountants Association, 1523 L St., N. W., Washington 5, D. C.

ORSA National Meeting

Date: May 25, 26, 1961
Place: Chicago, Illinois (Sheraton Blackstone Hotel)
Information: Dr. Donald H. Schiller, Caywood-Schiller Associates, 203 North Wabash Avenue, Chicago 1, Illinois

Western Systems Conference

Date: May 25, 1961
Place: Los Angeles, California (Statler-Hilton Hotel)
Information: Systems and Procedures Association, 219 W. 7th St., Suite 516, Los Angeles 14, California

Eighth Annual Symposium on Computers and Data Processing, sponsored by Denver Research Institute

Date: June 22, 23, 1961
Place: Estes Park, Colorado (Elkhorn Lodge)
Program: Invited and offered papers on Components and Devices, Logic Design, Philosophy of Computer Design, and Computers and Education
Information: For information about symposium and submission of papers write to: W. H. Eichelberger, Denver Research Institute, University of Denver, Denver 10, Colorado

NMAA National Conference

Date: June 28-30, 1961
Place: Toronto, Canada (Royal York Hotel)
Information: R. Calvin Elliott, Executive Director, National Machine Accountants Association, 1750 West Central Road, Mt. Prospect, Illinois

Annual Conference of Northwest Computing Association

Date: July 21, 22, 1961
Place: University of British Columbia, Vancouver, B. C.
Information: Conference Information, Northwest Computing Association, Box 836, Seahurst, Washington

8th Annual International Meeting of The Institute of Management Sciences

Date: August 23-26, 1961
Place: Brussels, Belgium (Palace of Congresses)
Information: TIMS, Box 273, Pleasantville, New York

Association for Computing Machinery National Conference

Date: September 5-8, 1961
Place: Los Angeles, California (Statler-Hilton Hotel)
Information: A. C. M. 1961 National Conference, Ben Handy, Litton Systems, 5500 Canoga Ave., Woodland Hills, Calif.

NABAC National Convention (The Association for Bank Audit, Control, and Operation)

Date: September 11-13, 1961
Place: Chicago, Illinois
Information: NABAC, 38 South Dearborn Street, Chicago 3, Illinois

International Systems Meeting

Date: October 8-11, 1961
Place: Cleveland, Ohio (Hotel Statler and Hotel Pick-Carter)
Program: "Systems Management in Transition"
Information: Systems and Procedures Association, 817 Penobscot Building, Detroit 26, Michigan

Computer Applications Symposium, sponsored by Armour Research Foundation

Date: October 24, 25, 1961
Place: Chicago, Illinois (Terrace Casino, Morrison Hotel)
Information: Robert B. Brausch, Armour Research Foundation, 10 West 35th Street, Chicago 16, Illinois

Institute on Electronics in Management, sponsored by The American University

Date: October 30--November 3, 1961
Place: The American University, Washington, D. C.
Information: Prof. Lowell H. Hattery, Director, Center for Technology and Administration, The American University, 1901 F Street, N. W., Washington 6, D. C.

TIMS-ORSA 2nd National Meeting

Date: November 8-11, 1961
Place: San Francisco, California (Jack Tar Hotel)
Information: The Institute of Management Sciences, Box 273, Pleasantville, N. Y.

1961 Eastern Joint Computer Conference

Date: December 12-14, 1961
Place: Washington, D. C. (Sheraton-Park Hotel)
Theme: Computers--Key to Total Systems Control
Papers: Papers are being sought in following general areas: Business Management Control, Military and Space Command Control Systems, Industrial Process Control, Real Time Systems, Network Control, Man-Machine Systems, Self Organizing Systems, High Speed Digital Data Communications. Submit papers to: Bruce G. Oldfield, IBM Federal Systems Division, 326 E. Montgomery Ave., Rockville, Md. before June 20, 1961.

## References

DATA PROCESSING DIGEST does not provide copies of the original material digested or reviewed in this issue. The publishers' addresses are listed below for your convenience in writing to them for more complete information.

Auditgram
38 South Dearborn St.
Chicago 3, Illinois

Behavioral Science
Mental Health Research Institute
University of Michigan
Ann Arbor, Michigan

Bulletin of the Provisional International Computation Centre
Palazzo degli Uffici, Zona dell' E. U. R. Rome, Italy

Burroughs Clearing House
2nd and Burroughs Ave.
Detroit 32, Michigan

Business
Mercury House
109-119 Waterloo Road
London SE 1, England

The Controller
Two Park Avenue
New York 16, New York

Computing News
Box 261
Thousand Oaks, Calif.

Data Processing
Gille Associates
22nd Floor, Book Tower
Detroit 26, Michigan

Data Processing
Illiffe Production Publications Ltd.
Dorset House, Stamford St.
London SE 1, England

Internal Auditor
120 Wall St.
New York 5, New York

Interscience Publishers
250 Fifth Ave.
New York 1, New York

Richard D. Irwin Inc.
1818 Ridge Road
Homewood, Illinois

Journal of the Academy of Management
1007 W. Nevada St.
Urbana, Illinois

Journal of Industrial Engineering
145 N. High St.
Columbus 15, Ohio

Journal of Machine Accounting
1750 W. Central Rd.
Mt. Prospect, Illinois

Management Science
250 North Street
White Plains, New York

McGraw-Hill Book Co. Inc.
330 West 42nd St.
New York 36, New York

NABAC
38 S. Dearborn St.
Chicago 3, Illinois

Office Equipment and Methods
Maclean Hunter Publishing Co.
University Ave.
Toronto, Canada

Science
1515 Massachusetts Ave. N. W.
Washington 5, D.C.

Systems and Procedures
4463 Penobscot Bldg.
Detroit 26, Michigan

Systems Magazine
Remington Rand
315 Fourth Avenue
New York 10, New York

Systems Management
10 E. 40th St.
New York 16, New York

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